Marine Safety Center Guidelines for Review of Liftboat Leg Strength

Procedure Number: T1-37 Revision Date: 05/05/00

References

a. 46 CFR Subchapter I, Part 92

b. 46 CFR Subchapter L, Part 134

c. Navigation and Vessel Inspection Circular 8-91, "Initial and Subsequent Inspection of Existing, Uncertificated Offshore Supply Vessels, including Liftboats"

d. ABS Rules for Building and Classing Mobile Offshore Drilling Units, 1985

e. ABS Rules for Building and Classing Mobile Offshore Drilling Units, 1994

Disclaimer

These guidelines were developed by the Marine Safety Center staff as an aid in the preparation and review of vessel plans and submissions. They were developed to supplement existing guidance. They are not intended to substitute or replace laws, regulations, or other official Coast Guard policy documents. The responsibility to demonstrate compliance with all applicable laws and regulations still rests with the plan submitter. The Coast Guard and the U. S. Department of Transportation expressly disclaim liability resulting from the use of this document.

Contact Information

If you have any questions or comments concerning this document, please contact the Marine Safety Center by e-mail or phone. Please refer to the Procedure Number: T1-37

E-mail: customerservicemsc@msc.uscg.mil
Phone: 202-366-6480.

General Review Guidance

- Determine applicability to Subchapter (I) or Subchapter (L):
  - For Liftboats certificated under 46 CFR, Subchapter I:
    - Use a wind speed = 50 knots for operations inside the boundary line
    - Use a wind speed = 70 knots for operations outside the boundary line
    - Submitter may also submit 100 knot wind speed calculations to elevate at a location where the vessel can survive 100 knot winds
  - For Liftboats certificated under 46 CFR Subchapter L, 70 knot and 100 knot wind speed calculations must be submitted.

- Ensure the operator specified "operating conditions" (water depth, wave height, wave period, etc.) are reasonable. These conditions are set by the operator as allowed by ABS (Reference (d)1.21 for Subchapter (I) and Reference (e) 3/2.1.1 for Subchapter (L)).

- Verify deck load is equal to maximum deck load used for intact stability analysis.

- Determine the critical angle (theta) and distances (X1 and X2) at which the environmental forces act..

- Determine the projected wind area, force, and moment for each vessel component (such as deck house, 01 level, legs, hull, deck load, cranes, etc.) and sum to get total wind loads. (Reference (d) 3.5.2 and Reference (e)3/2.1.2).

- Determine the section modulus (SM) for the leg section.

- Determine the wave force and moment (Reference (d) Appendix A and Reference (e) Part 3, Appendix 3/A present a cut & dry approach based on empirical data. Just follow the example and use the tabulated appendix values.).

- Determine the current drag force and moment (Reference (d) 3.5.4 and Reference (e) 3/2.1.4).

- Combine the wind, wave, and current forces and moments to determine the total environmental forces and moments (Note – the wave and drag forces are multiplied by the number of legs to account for the forces and moments on each leg.).

- Determine the leg deflections due to environmental loading conditions using standard beam deflection equations.

- Determine the moments at the top of the leg, Mr, and the reaction force, Lc, at the base of the leg.

- Determine the axial load at the leg support, L, where L = Lc – load due to pad weight, Lp, - the axial load due to the leg weight above the support, La.

- Determine Fa = Fcr / FS (Reference (d) 3.11.3 and Reference (e)3/4.3.3).

- Determine Fb = Fy / 1.25 (Reference (d)3.11 and Reference (e)3/4.3.2).
- Determine fa = L / A
- Determine fb = Mr / SM
- Verify fa/Fa + fb/Fb $\leq$ 1.0 (Reference (d)3.11.4 and Reference (e)3/4.3.4)

Attachments

(1) Figure (1) Determining the Critical Angle, X1, and X2

(2) Sample Leg Strength Spread Sheet Calculation

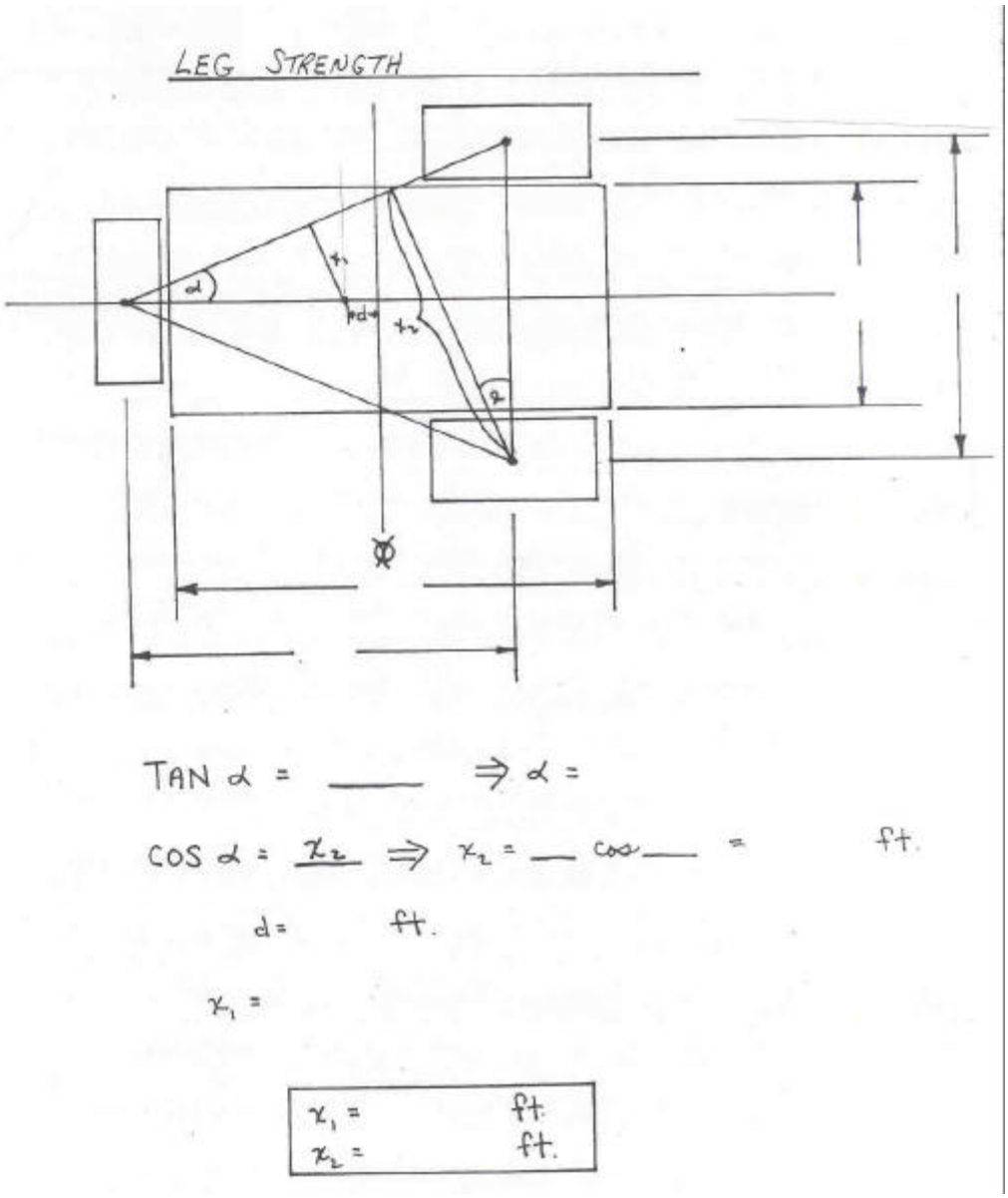

Figure (1) Determining the Critical Angle, X1 and X2

Attachment (1)

Attachment (2): Sample Leg Strength Spread Sheet Calculation

Sample Leg Strength Calculations

water depth 24 ft, wave height 4ft, wave period 12.5 seconds 50 knots

Vessel Name =

Date = 4/6/99

OD =	20.25 inches
t (thickness) =	0.375 inches
ID = OD - 2t =	19.5 inches
r = OD/2 =	10.125 inches
critical angle = theta =	20.22 degrees
# of x-axis stiffners =	2
width of x-axis stiffner =	3 inches
t of x-axis stiffner =	0.38 inches
# of y-axis stiffners =	0
width of y-axis stiffner =	0 inches
t of y-axis stiffner =	0 inches
width of rack =	3 inches
t of rack =	1 inches
A1 = t*(D-t)*pi =	23.41 inches ^2
A2 = (# x stiffners)*(width of x stiffner)*(t of x stiffner) =	2.25 inches ^2
A3 = (# y stiffners)*(width of y stiffner)*(t of y stiffner) =	0.00 inches ^2
A4 = (width of rack)*(t of rack) =	3.00 inches ^2
A = A1 + A2 + A3 + A4 =	28.66 inches ^2
delta x = A4 * (r + (t of rack/2)) / A = neutral axis	1.11 inches
Ix1 = pi / 64 * (OD^4 – ID^4) =	1156.56 inches^4
Ix2 = (t of x stiffner)^3 * (w of x stiffner)/12 *(# of x stiffner) =	0.03 inches^4
Ix3 = (w of y stiffner)^3 *(t of y stiffner)/12*(# y stiffner) + A3*(distance from x-axis to center of y stiffner)^2 =	0.00 inches^4
Ix4 = (width of rack)^3*(t of rack)/12 =	2.25 inches^4
Ix = Ix1 + Ix2 + Ix3 + Ix4 =	1158.83 inches^4
Iz1' = Ix1 =	1156.56 inches^4
Iz2' = (w of x stiffner)^3 *(t of x stiffner)/12*(# x stiffner) + A2*(distance from y-axis to center of x stiffner)^2 =	154.83 inches^4

Iz3' = (w of y stiffner)^3 * (t of y stiffner)/12 *(# of y stiffner) =	0.00 inches^4	
Iz4' = (t of rack)^3 * (w of rack) / 12 + (A4 * (r + t of xstiffner /2))^2) =	319.29 inches^4	
Iz' = Iz1' + Iz2' + Iz3' + Iz4' =	1630.68 inches^4	
Iy = Iz' - A * (delta x^2) =	1595.23 inches^4	
Iz = (Iz' + Ix)/2 + (Iz' – Ix)/2 * cos (critical angle theta) =	1441.71 inches^4	
rx = (Ix / A) ^0.5 =	6.36 inches	0.529853 feet
SM = Iz/ [r + (delta x *cos (theta))} =	139.35 inches^3	

Enviromental Loads

wave height = hw =	4.00 feet	
wave period = T =	12.50 seconds	
still water depth = h =	24.00 feet	
wind speed = Vk = 46 CFR 134.140 requires 70 or 100 knots	50.00 knots	
Current =	5.00 knots	8.45 feet/sec
air gap =	2.86 feet	

Using ABS MODU Rules 1994 Part 3 Appendix 3/A:

hw / T^2 =	0.03	
h / T^2 =	0.15	
hw / h =	0.17	
From Figure A.1 lo/hw =	0.56	
lo = hw * (lo/hw) =	2.24 feet	
hull clearance = Air gap - lo =	0.62 feet	
From Figure A.2 La/Lo =	0.42	
From Figure A.3 Lw/La =	1.070	
Lw = (Lw/La)*(La/Lo)kT^2 =	359.52 feet	
From Figure A.4 Kdm =	15.00 feet/sec	
Cd = may be taken as 0.62 (ABS 1994 MODU 3/2.1.3c)	0.62	
Cm = may be taken as 1.8 (ABS 1994 MODU 3/2.1.3c)	1.80	
rho =	1.99 slugs/ft^3	
OD =	1.69 feet	
Fdm = 0.5*Cd*OD*hw^2*Kdm =	249.72 lbsf	
From Figure A.5 Sd/h =	0.63	
Sd = (Sd/h)*h =	15.12 feet	
Mdm = Fdm * Sd =	3775.75 ft*lbsf	
From Figure A.6 Kim =	17	
Fim = 0.5 * Cm * rho * D^2 * hw * Kim =	346.64 lbsf	
From Figure A.7 Si/h =	0.74	

Si = (Si/h)*h =	17.76	feet
Mi = Fim * Si =	6156.26	ft*lbsf
Fim/Fdm =	1.39	
if Fim/Fdm > 1.0 use equation; if < 1.0 use Figure A.8		
Fm/Fdm = 1.0056* (Fim/Fdm) + 0.3776 =	1.73	
Fm = Fdm * (Fm/Fdm) =	432.88	lbsf
Mtm = (Fm/Fdm) * Mdm =	6545.18	ft*lbsf
S = Mtm/Fm =	15.12	feet
(h*D^2)/(Lw*hw^2) =	0.01	
From Figure A.9 Beta =	20.00	degrees
Xm = Beta * Lw/360 =	19.97	feet

Current Drag (per leg)

Cd =	0.62	
rho =	1.99	slugs/ft^3
water depth = h =	24.00	feet
OD =	1.69	feet
Af = OD * water depth =	40.50	feet^2
V = current speed =	8.45	feet/sec
Fd = 0.5*Cd*rho*V^2*Af =	1780.95	lbs
lever arm = h/2 =	12.00	feet
Md = lever arm * Fd =	21371.35	ft*lbsf

wind loads

leg length =	40.00	feet
critical angle = theta =	20.22	degrees

Item	H (ft)	L (ft)	W (ft)	H*L* cos(theta)
Hull	5.67	45	20.00	239.43
maindeck deck house	7.00	19	14.00	124.80
01 level deckhouse	0.00	0	0.00	0.00
02 level deckhouse	0.00	0	0.00	0.00
pilot house	0.00	0	0.00	0.00
deck load	8.00	15	18.00	112.60
stbd crane	1.30	49	1.30	59.77

stbd crane pedestal	10.00	2.5	2.50	23.46
port crane	0.00	0	0.00	0.00
port crane pedestal	0.00	0	0.00	0.00
Legs	16.00	1.69	1.69	25.34

Item	H*W* sin(theta)	total area	h (ft)	Ch
Hull	39.19	278.62	22.84	1
maindeck deck house	33.87	158.67	29.17	1
01 level deckhouse	0.00	0.00	32.67	1
02 level deckhouse	0.00	0.00	32.67	1
pilot house	0.00	0.00	32.67	1
deck load	49.77	162.37	29.67	1
stbd crane	0.58	60.36	26.32	1
stbd crane pedestal	8.64	25.00	30.67	1
port crane	0.00	0.00	25.67	1
port crane pedestal	0.00	0.00	25.67	1
Legs	9.33	104.00	28.00	1

Item	Cs	Force (lbs)	Moment (ft*lbs)
Hull	1	2354.34	53761.27
maindeck deck house	1	1340.80	39111.21
01 level deckhouse	1	0.00	0.00
02 level deckhouse	1	0.00	0.00
pilot house	1	0.00	0.00
deck load	1	1372.07	40709.23
stbd crane	1.5	765.04	20135.93
stbd crane pedestal	1.5	316.88	9718.56
port crane	1.5	0.00	0.00
port crane pedestal	1.5	0.00	0.00
Legs	0.5	439.42	12303.66
		---	---
F (Force, lbf) = 0.00338 * Vk^2 (knots) * Ch *Cs * Area		6588.54	175739.86

Ch = height coefficient from 1994 ABS MODU Rules Table 3/2.2

Cs = shape coefficient from 1994 ABS MODU Rules Table 3/2.1

Enviromental Force Loads

# legs =	3
Ftot = #legs * Fm + #legs * Fd + Fw =	13230.03 lbs

Mtot = #legs * Mtm + #legs*Md + Mw =	2.59E+05 ft*lbs

Critical Buckling Stress

Baseline to bottom of stern =	2.67 feet
Air Gap =	2.86
h =	24.00
l = unsupported leg length=h+air gap+(baseline to bot.Stern)	29.53 feet
L = 2 * l =	59.06
Minimumu Area = A =	28.66 in^2
rE = rX =	0.53 feet
k = 2	2.00
E =	3.00E+07 psi
Fy = yield strength =	52000.00 psi
((2*pi^2*E)/Fy)^0.5 =	106.71
k*l/rE =	111.46
if k*l/rE > ((2*pi^2*E)/Fy)^0.5 then use the following	
Fcr = (pi^2*E)/(k*l/rE)^2	23831.18 psi
Fr = Ftot/#leg	4410.01 lbs
fd = Fd/h	74.21 lb/ft
Fm =	432.88 lbs
I = Iz =	1441.71 in^4
a = l - h =	5.53 feet
b = l - Sd =	14.41 feet

deflection due to Fr

dr = Fr*l^3/3EI	1.512355 inches

deflection due to fd

dd = fd(3l^4 - 4la^3 + a^4)/(24EI)	0.27945 inches

defelction due to Fm

dm = Fm*b^2*(3*l-b)/(6EI)	0.04440 inches
deflection = dr - dd – dm =	1.19 inches

moment at top of leg

Mr = Fr *l - Fm * b - Fd * (a + h/2) =	92769.74 ft*lbs

Leg Loading at Full Load Condition

x1 = (cl of aft pad to amidships + lcg)sin (theta) =	9.35 feet
x2 = (cl side pad to cl side pad)cos(theta) =	27.37 feet
deflection =	0.09904 feet

W = full load displacement =	83.79 ltons
Mtot =	2.59E+05 ft*lbs

moment at base of legs:

Lc*x2 = W(x1+defelction)+Mtot	
Lc = (W(x1+deflection)+Mtot)/x2 =	74.28 kips

for load at top of leg subtract leg & pad weight:

weight of leg + pad =	9.58 kips
L = Lc - (leg+pad weight)*#legs	45.54 kips

Safety Factor at top of Leg

fa = L/A	1.59
Fa = Fcr/1.44	16.55
fb = Mr/SM	7.99
Fb=Fy/1.25	41.60

SF = fa/Fa + Fb/Fb	SF must be < 1.0 !!!	0.29